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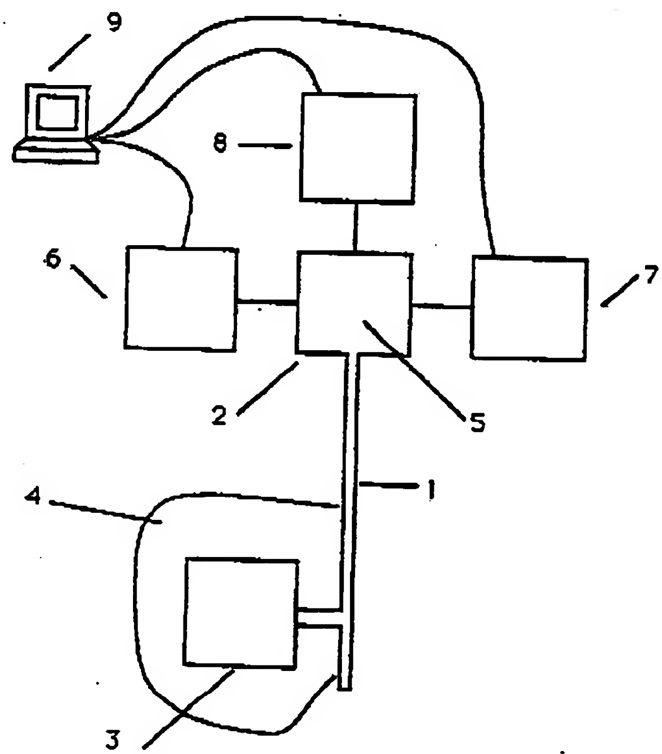
(54) Title: REMOTELY DEPLOYABLE PRESSURE SENSOR

(57) Abstract

Apparatus for measuring pressure, which apparatus comprises a pressure valve (3) for location at a point at which pressure is to be measured, a primary tube (1) containing a fluid for linking the pressure valve (3) to a control point where the pressure information is required, pressure control means (6) for changing the pressure of the fluid within the primary tube (1), volume measuring means for measuring changes in volume of the fluid within the primary tube (1) as the pressure is varied, and pressure measuring means (7) for measuring the pressure at some point within the fluid.



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REMOTELY DEPLOYABLE PRESSURE SENSOR

FIELD OF THE INVENTION

In many instances, it is necessary to measure a physical parameter at some point in a harsh environment, often a considerable distance from where the information is needed. Such an example is the measurement of pressure at the bottom of an oil well which presents significant problems for the deployment of pressure sensors.

BACKGROUND OF THE INVENTION

There are three main problems associated with the deployment of sensors in harsh environments. Firstly, there are the practical difficulties in getting the sensor to the correct position in the first instance and then, possibly, retrieving it later. Secondly, either the sensor must have a means of storing information, or it must have a means of communicating between the sensor itself and the information processing system. Thirdly, the sensor must be robust enough, not only to take the rigours of deployment, but also be able to function successfully for significant periods of time under harsh conditions. These three aspects are of particular importance in the oil extraction industry. The measurement of pressure at the bottom of an oil well is important for the efficient extraction of the oil reserves. The industry takes two different approaches. In the one case, a measurement system is lowered down the production tube of the well to take and record measurements for a short period before being returned to the surface. Although convenient for use with existing wells and only requiring short term stability of calibration, this approach gives limited information and interferes with the production of oil. In the other case, a measurement system is permanently installed during the construction of the oil well. This has the advantage of giving continuous measurements without interfering with oil production but places very severe requirements on the measurement stability of the sensor and its ability to

withstand the high pressures and temperatures in the well for many years. Should such a sensor fail, or doubts be cast upon its accuracy, then the current practice would be to abandon it since it would be too expensive to replace. The permanent installation of a measurement system at the bottom of the oil well also requires significant technical problems to be solved in transferring information via metal or optical fibre cables, or radio links, up to the surface.

The present invention describes a pressure sensor which may be either temporarily or permanently deployed in a convenient fashion, using existing technology familiar to industries such as the oil industry.

SUMMARY OF THE INVENTION

An aim of the present invention is to provide apparatus for the measurement in a hostile environment preferably at a remote location.

BRIEF DESCRIPTION OF THE INVENTION

According to the present invention, there is provided apparatus for measuring pressure, which apparatus comprises a pressure valve for location at a point at which pressure is to be measured, a primary tube containing a fluid for linking the pressure valve to a control point where the pressure information is required, sealing means for sealing the primary tube so as to form a closed system, pressure control means for changing the pressure of the fluid within the primary tube, volume measuring means for measuring changes in volume of the fluid within the primary tube as the pressure is varied, and pressure measuring means for measuring the pressure at some point within the fluid.

The pressure valve may be a device which may exist in a number of states according to the relative pressure difference between an external and an internal pressure, and whose volume depends upon

this pressure difference. The external pressure is that which surrounds the pressure valve and is usually the pressure to be measured. The internal pressure is that of the fluid contained in the primary tube at the point of connection between the pressure valve and the primary tube. When the external pressure is higher than the internal pressure by more than a fixed limit, the pressure valve contains a fixed volume of the primary tube fluid which constitutes one state, the OFF state. Similarly, when the external pressure is lower than the internal pressure by more than a different fixed limit, the pressure valve contains a different fixed volume of the primary tube fluid, which constitutes a second state, the ON state. A third state, the ACTIVE state, occurs when the external pressure lies between these fixed pressure limits relative to the internal pressure. In which case, the volume of primary tube liquid contained by the valve depends upon the pressure difference in some consistent fashion and lies between the two volume limits. When the pressure valve takes this form, the whole apparatus is a sealed system with no direct contact between the fluid in the primary tube and the external environment.

Alternatively, the pressure valve may be a device which may exist in a number of states according to a control signal provided separately. In addition, the pressure valve may not contain a mechanical interface between the pressure in the primary tube and that in the region to be measured, and so there will be direct contact between the fluid in the primary tube and the external environment when the pressure valve is in the ACTIVE state.

The primary tube may be preferably narrow bore hydraulic tubing whose change in dimension with pressure is either small or well-known. The fluid contained by the primary tube may be a hydraulic oil, or any other fluid that is virtually incompressible or whose compressibility is well-known.

The sealing means may take any form that ensures that all times the pressure within the primary tube may be adequately

controlled both in accuracy and range. In particular, the pressure in the primary tube must be able to match the pressure to be found in the external environment to be measured, so that the pressure valve may operate as intended and the pressure be measurable.

The pressure control means may be any apparatus which permits the pressure to be changed from one value to another under some external control. Such apparatus could be a force acting on a piston inside a cylinder containing the primary tube fluid.

The pressure measuring means may be any convenient apparatus which converts pressure into an indication such as a pressure dial gauge or a pressure transducer.

The volume measuring means may be any apparatus suitable for measuring the change in volume of the fluid within the primary tube and which has the sensitivity to detect the change in volume of the pressure valve as it changes state. An example of such apparatus would be the measurement of the position of a piston in a cylinder where the piston is used to determine the pressure in the primary tube fluid.

In one embodiment of the present invention, the means of changing the pressure, the volume measuring means, and the pressure measuring means, are all located together at the control point.

In a preferred embodiment of the apparatus, there is also provided means of measuring the temperature along the length of the primary tube. The temperature measuring means may be preferably an optical fibre distributed temperature sensor, either outside or inside the primary tube. An example of such a sensor is the York Sensors Limited DTS80 which is commercially available.

In another preferred embodiment of the apparatus, there is also provided pressure sensing means of such a dimension and structure that it it is placeable inside the primary tube, locating means for

locating the pressure sensing means at any desired point within the primary tube, and transmitter means for transmitting the pressure information from the pressure sensing means to the control point. More preferably there is also provided means for removing the pressure sensing means. The pressure sensing means may be a passive optical fibre sensor and the transmitter means may be optical fibre cables. More preferably, the pressure sensing means may be a passive optical fibre sensor such as the polarimetric interferometer optical fibre pressure and temperature sensor disclosed in UK patent application No.9203471.9.

A further embodiment includes a secondary tube which connects the furthest point at which a pressure sensor may be located in the primary tube to the control point so that a return path for the fluid in the primary tube is provided. It is then possible to locate the pressure sensor by means of controlling the flow of fluid through the primary and secondary tubes, by, for example, a pump with the capability of reversible flow.

During operation, the pressure of the fluid in the primary tube is increased, and the volume monitored, until there is a change in volume equivalent to the change of a pressure valve from the OFF state to the ON state. The pressure is then held constant in the ACTIVE state between the two volume limits by the pressure control means at some defined point, preferably the mid-point. The pressure at the pressure valve may then be computed from (a) the measured pressure obtained from the pressure sensing means, (b) the physical separation of the location of the pressure valve and the point at which the pressure is measured using the effect of gravity on hydrostatic pressure and the effect of temperature upon density of the fluid, and (c) any residual correction needed to compensate for any pressure loss caused by activation of the pressure valve. In general, it is desirable to locate the pressure sensing means close to the pressure valve in order to minimise the required correction to the measured pressure. In order for the volume change arising from the change in states of the pressure valve to be detected, it is necessary

for the compressibility of the fluid in the primary tube to be low or well-known, and for the change in volume of the primary tube and the connected volumes with pressure to be small or well-known.

If $P(h)$ and $\rho(h,T)$ are the pressure and density respectively, at height h and temperature T, then the pressures at two different heights a and b are related by well-known theory as follows:

$$P(a) = P(b) + g\int_a^b \rho(h,T)dh$$ where g is the gravitational constant.

Thus, in order to be able to compute the pressure at one height from measurements made at another, it is necessary to know the height difference as well as the density of the fluid as a function of height. Where the temperature of the fluid is approximately constant, sufficient accuracy may be achieved simply by assuming a uniform density of the liquid. However, where large changes in temperature occur, and where maximum accuracy is required, it will be necessary to measure the temperature of the fluid as a function of height and or minimise the height difference between the height at which the pressure is required and the height at which it is measured.

If the pressure difference between that pressure needed to put the pressure valve into the OFF state and that pressure needed to put it into the ON state is known, then it will be possible to calibrate the pressure sensitivity system by varying the pressure from the one state to the other and noting the volume change. This calibration may be then used to convert a measured volume change into a calculated pressure change when the pressure valve is held in the active region.

In another preferred embodiment, there are provided additional pressure valves connected at different points along the primary tube, and distinguishing means for distinguishing the state of a particular pressure valve as the pressure is changed. Such distinguishing means may be implicit, such as, for example, when the pressure valves are

used to measure the pressure at a variety of different heights and where the pressure is known to be strongly correlated with height, then identical pressure valves may be used and the point at which the pressure is being measured deduced from the sequence of volume changes with pressure change. Another example where the distinguishing means are implicit is when pressure valves of different volumes are used so that the valve is uniquely identified by its volume change as the pressure is varied. For example, each pressure valve having twice the volume of its predecessor along the primary tube would be suitable.

In one preferred embodiment, there is provided one or more pressure sensing means located at each pressure valve so that it is not necessary to take into account the position of the pressure valve by computing a correction.

In another embodiment, there are provided more than one pressure sensing means positioned at different locations as convenient, but not necessarily adjacent to a pressure valve. For example, the temperature at a pressure valve may be too high to permit the location of the pressure sensing means at that point. However, a pressure sensing means at the control point may not be able to provide suitable response to rate of change in pressure at the pressure valve because the primary tube is of such a bore and such a length that its impedance restricts the rate of change in pressure. In which case, it would be advantageous to position a pressure sensing means at some intermediate point in the primary tube between the pressure valve and the control point.

In another embodiment the pressure valve is operated by separate means, either hydraulic or electric, so that the state of the valve may be controlled at will. This may be advantageous for both safety and operational purposes, but does require additional equipment. In addition, there may be no mechanical interface between the fluid in the primary tube and that in the external region to be measured when the pressure valve is in the ACTIVE state. This

has the advantage that the properties of such an interface do not affect the pressure measurement, but has the disadvantage that there may be loss of fluid from the primary tube. If this were to occur then there would need to be provided means of ensuring that there was sufficient fluid available in the apparatus at all times for satisfactory performance.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described solely by way of example and with reference to the accompanying drawings in which:

Figure 1 is a diagram of a pressure sensor according to the present invention;

Figure 2 is a diagram of a suitable pressure valve;

Figure 3 is a diagram of part of a preferred embodiment of the present invention, in which an optical fibre distributed temperature sensor is included;

Figure 4 is a diagram of part of a preferred embodiment of the present invention, in which an optical fibre pressure sensor is included;

Figure 5 is a diagram of a preferred embodiment of the present invention, in which a secondary tube is included;

Figure 6 is a diagram of part of a preferred embodiment of the present invention in which more than one pressure valves and more than one pressure sensors are included; and

Figure 7 is a diagram of a preferred embodiment of the present invention in which the pressure valve is switched by switch means.

DETAILED DESCRIPTION OF THE INVENTION

With reference to Figure 1, a primary tube 1 is connected at one end to a chamber 2 and at the other end to a pressure valve 3 which is situated in region 4 whose pressure is to be measured. The primary

tube 1, chamber 2, and valve 3, constitute a single connected volume and is filled with hydraulic oil 5, or some other virtually incompressible fluid, or one whose compressibility is well-known. The pressure in the chamber 2 is controlled by pressure control means 6, and is measured by pressure measuring means 7. The volume of the hydraulic oil 5 is measured by volume measuring means 8. Computing and controlling means 9 is used to change the pressure in the chamber 2 with the pressure control means 6 until a change in volume, caused by the pressure valve 3 changing state, is detected by the volume measuring means 8. Computing and controlling means 9 is then used to compute the pressure in region 4 from the pressure in chamber 2 obtained from the pressure measuring means 7, and the known height difference between the pressure valve 3 and chamber 2, and the known density of the hydraulic oil 5.

Figure 2 illustrates an example of a suitable pressure valve 3 connected to primary tube 1. A membrane 10 is clamped between two blocks 11 so as to form two isolated volumes 12, on either side of the membrane, where one volume is exposed to the pressure in the region to be measured 4, and the other volume is exposed to the pressure in the primary tube 1. The inner surfaces 13 of the blocks 11 are such that, once the pressure on one side of the membrane 10 exceeds that on the other side by some threshold value, the membrane 10 will be constrained by the surface 13 so that there is little further change in volume as the pressure difference increases. The change in volume as the membrane 10 moves from one surface 13 to the other is sufficient to be detected by the volume measuring means 8 shown in Figure 1.

Figure 3 shows a preferred embodiment of the apparatus in which the temperature of the hydraulic oil 5 is measured along the length of the primary tube 1 between the pressure valve 3 and the chamber 2 (not shown in this figure) using the sensing optical fibre 14 of a distributed temperature sensing measurement system. Computing and controlling means 9 (not shown in this figure) is further used to derive the pressure difference between the pressure

valve 3 and chamber 2 (not shown in this figure) from the known density of the hydraulic oil 5 as a function of temperature.

Figure 4 shows a preferred embodiment in which pressure sensing means 15 is placed inside the primary tube 1 close to the pressure valve 3. The pressure sensing means 15 may be additional to, or replace, the pressure measuring means 7 shown in Figure 1. The measured pressure information is transmitted from the pressure sensing means 15 to the computing and controlling means 9 (not shown in this figure) by a metal or optical fibre cable 16.

The pressure sensing means 15 may be operated in two different modes. In the first mode, when the pressure valve 3 is in the ACTIVE state, pressure sensing means 15 is measuring the pressure of an external region 4, and, in the second mode, when the pressure valve 3 is in the ON or OFF state, pressure sensing means 15 is measuring the pressure determined by the pressure at the control point plus the hydrostatic pressure of the column of fluid 5 in the primary tube 1 independently of the pressure in region 4. This permits the checking, conditioning and determination of a variety of performance parameters of the pressure sensing means 15, such as sensitivity and repeatability, without the need to remove the pressure sensing means 15 from primary tube 1, which is particularly advantageous.

In many uses of the present invention, it will be desirable to provide additional means of inserting and retrieving the pressure sensing means 15 shown in Figure 4. Such means are provided in a preferred embodiment as shown in Figure 5. The pressure sensing means 15 is attached to a piston 17 which is of a size and shape to create a significant obstruction to flow of the hydraulic oil 5 past the piston 17 so that piston 17 moves with the flow. A secondary tube 18 is provided which connects the end of the primary tube 1 to the chamber 2. A reversible pump 19 is used to cause a flow in either direction around the circuit made up of chamber 2, the primary tube 1, and secondary tube 18. The piston 17 will be carried by the flow

and hence will insert or retrieve the pressure sensing means 15 according to the direction of the flow as determined by the pump 19.

Figure 6 illustrates part of another preferred embodiment of the present invention, in which more than one pressure valve 3 is provided so that the pressure at several different regions 4 may be measured according to the present invention. The volume changes within the different pressure valves 3, as they change from their OFF states to their ON states, may be the same as, or different, from each other. In addition, a single pressure sensing means 15, or one adjacent to each pressure valve, may be provided.

In another embodiment, several pressure valves 3, each with different characteristics, are provided adjacent to each other such that they all measure the same region 4.

Figure 7 illustrates another preferred embodiment of the present invention in which the pressure valve 3 is switched between the ACTIVE state and the ON/OFF state by a slide or rotary valve 20, a separate hydraulic or electric line 21 and hydraulic or electric control means 22. In this embodiment, there is no mechanical interface, such as the membrane 10 shown in Figure 2, between the fluid 5 in the primary tube 1 and the fluid in the region 4 to be measured, when pressure valve 3 is in the ACTIVE state. Thus it would not be necessary to take into account the properties of the mechanical interface, such as the membrane 10 shown in Figure 2.

In the embodiment shown in Figure 7, it is desirable to prevent fluid from region 4 entering primary tube 1, and it may also be desirable to flow fluid 5 through pressure valve 3 into region 4. Accordingly, reservoir means 23 may be provided in order to supply the volume of fluid 5 needed to compensate for the flow through pressure valve 3.

CLAIMS

1. Apparatus for measuring pressure, which apparatus comprises a pressure valve for location at a point at which pressure is to be measured, a primary tube containing a fluid for linking the pressure valve to a control point where the pressure information is required, sealing means for sealing the primary tube so as to form a closed system, pressure control means for changing the pressure of the fluid within the primary tube, volume measuring means for measuring changes in the volume of the fluid within the primary tube as the pressure is varied, and pressure measuring means for measuring the pressure at some point within the fluid.

2. Apparatus according to claim 1 in which the primary tube is narrow bore hydraulic tubing whose change in dimension with pressure is either small or well-known.

3. Apparatus according to claim 1 or claim 2 in which the fluid in the primary tube is a hydraulic oil.

4. Apparatus according to any one of the preceding claims in which the pressure control means is such as to permit the pressure to be changed from one value to another under an external control.

5. Apparatus according to claim 4 in which the pressure control means is an arrangement in which a force acts on a piston inside a cylinder containing the primary tube fluid.

6. Apparatus according to any one of the preceding claims in which the pressure means is a pressure dial gauge or a pressure transducer.

7. Apparatus according to any one of the preceding claims in which the volume measuring means is an arrangement in which measurement is effected of the position of a piston in a cylinder where the piston is used to determine the pressure in the primary tube fluid.

8. Apparatus according to any one of the preceding claims in which the pressure control means, the volume measuring means and the pressure measuring means are all located together at the control point.

9. Apparatus according to any one of the preceding claims and including temperature measuring means for measuring the temperature along the length of the primary tube.

10. Apparatus according to claim 9 in which the temperature measuring means is an optical fibre distributed temperature sensor, either outside or inside the primary tube.

11. Apparatus according to any one of the preceding claims and including pressure sensing means of such a dimension and structure that it is placeable inside the primary tube, locating means for locating the pressure sensing means at a desired point within the primary tube, and transmitter means for transmitting the pressure information from the pressure sensing means to the control point.

12. Apparatus according to claim 11 and including means for removing the pressure sensing means.

13. Apparatus according to claim 12 in which the transmitter means are optical fibres.

14. Apparatus according to any one of claims 11 to 13 in which the pressure sensing means is a passive optical fibre sensor.

15. Apparatus according to claim 14 in which the pressure sensing means is a polarimetric interferometer optical fibre pressure and temperature sensor.

16. Apparatus according to any one of the preceding claims and including a secondary tube which connects the furthest point at

which a pressure sensor may be located in the primary tube to the control point, so that a return path for the fluid in the primary tube is provided.

17. Apparatus according to claim 16 in which the pressure sensor is located by means of controlling the flow of fluid through the primary and secondary tubes.

18. Apparatus according to claim 17 in which the means of controlling the flow of fluid through the primary and secondary tubes is a pump with the capability of reversible flow.

19. Apparatus according to any one of the preceding claims and including additional pressure valves connected at different points along the primary tube, and means of distinguishing which valve is in which state when the pressure is changed.

20. Apparatus according to claim 19 in which one or more pressure sensors is located at each pressure valve so that it is not necessary to take into account the position of the pressure valve by computing a correction.

21. Apparatus according to any one of claims 1 to 19 and including additional pressure valves connected at the same point along the primary tube.

22. Apparatus according to any one of the preceding claims in which the pressure valve is switched between the ACTIVE state and the ON/OFF state by separate means than the pressure in the primary tube.

23. Apparatus according to claim 22 in which the pressure valve is switched between the ACTIVE state and the ON/OFF state using a slide or rotary valve, a separate hydraulic or electric line, and hydraulic or electric control means.

24. Apparatus according to claim 22 and 23 in which there is no mechanical interface when the pressure valve is in the ACTIVE state.

25. Apparatus according to claim 24 and including reservoir means for supplying fluid that may be lost through the pressure valve.

26. Apparatus for measuring pressure substantially as herein described with reference to the accompanying drawings.

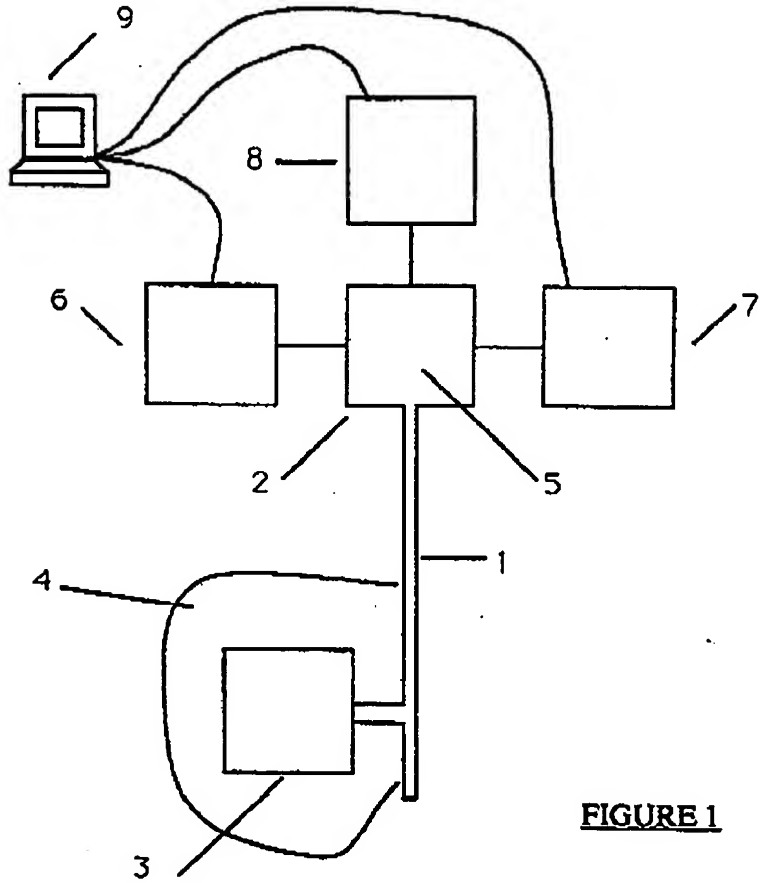

FIGURE 1

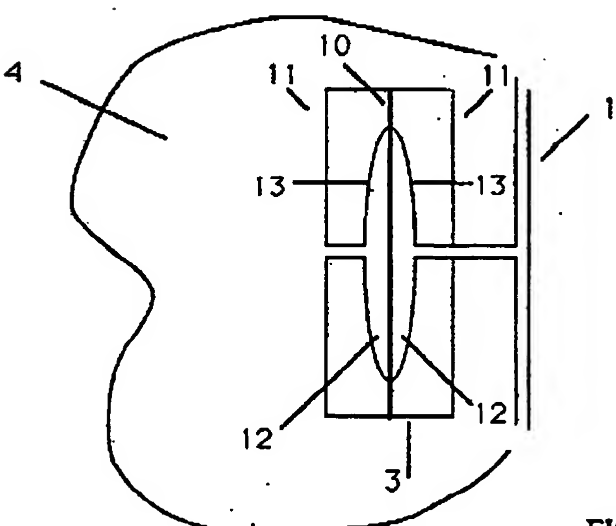

FIGURE 2

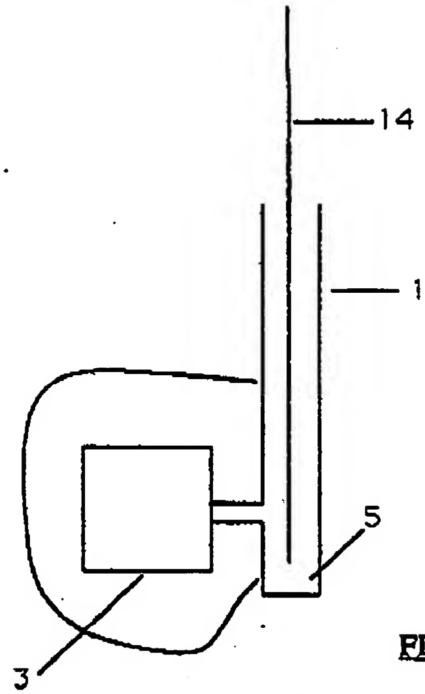

FIGURE 3

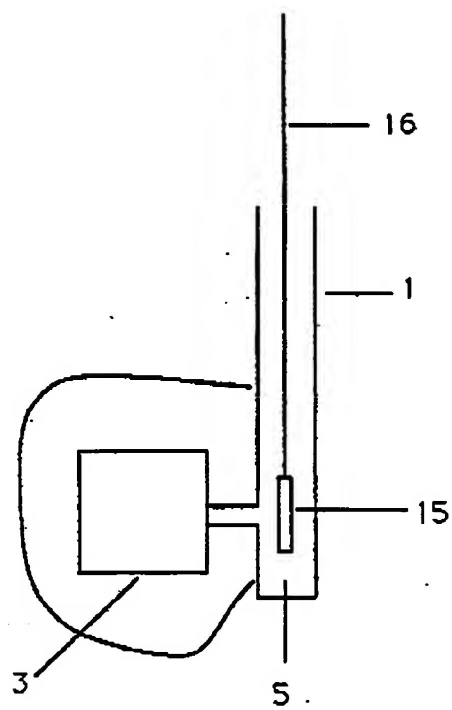

FIGURE 4

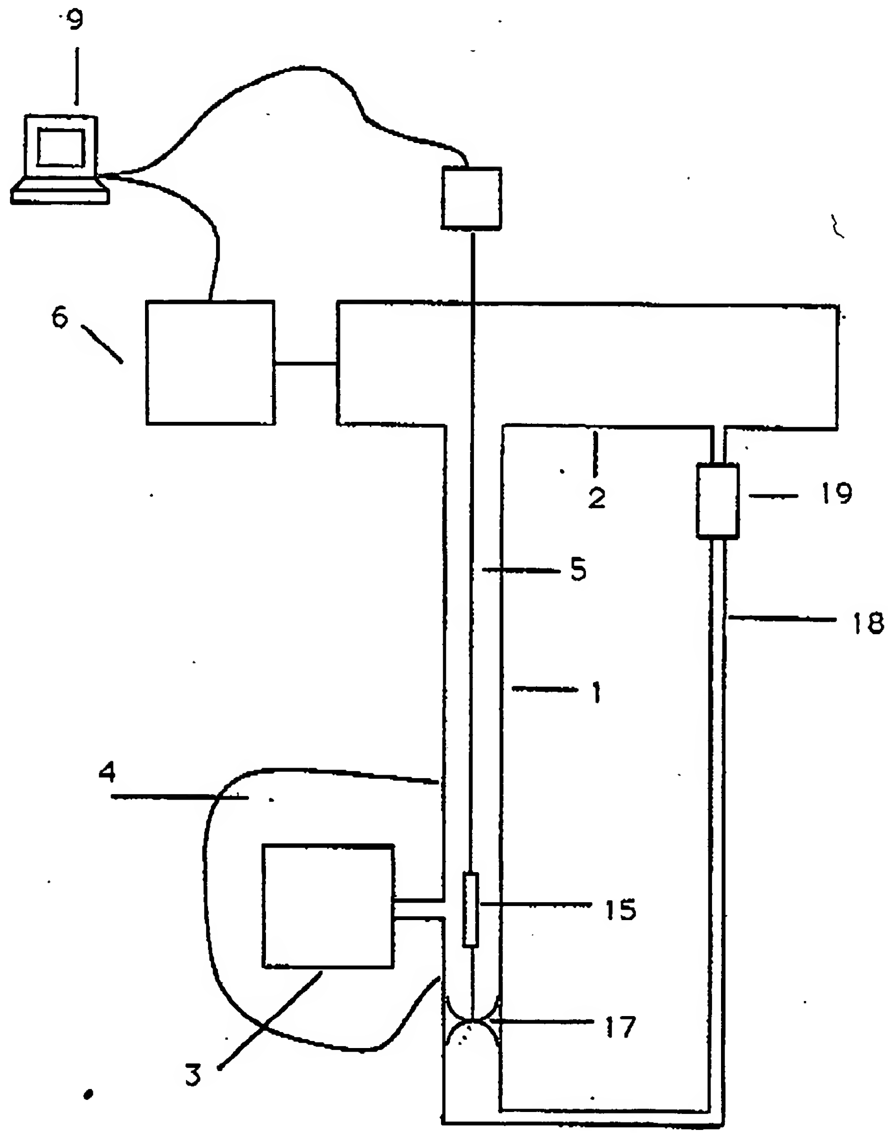

FIGURE 5

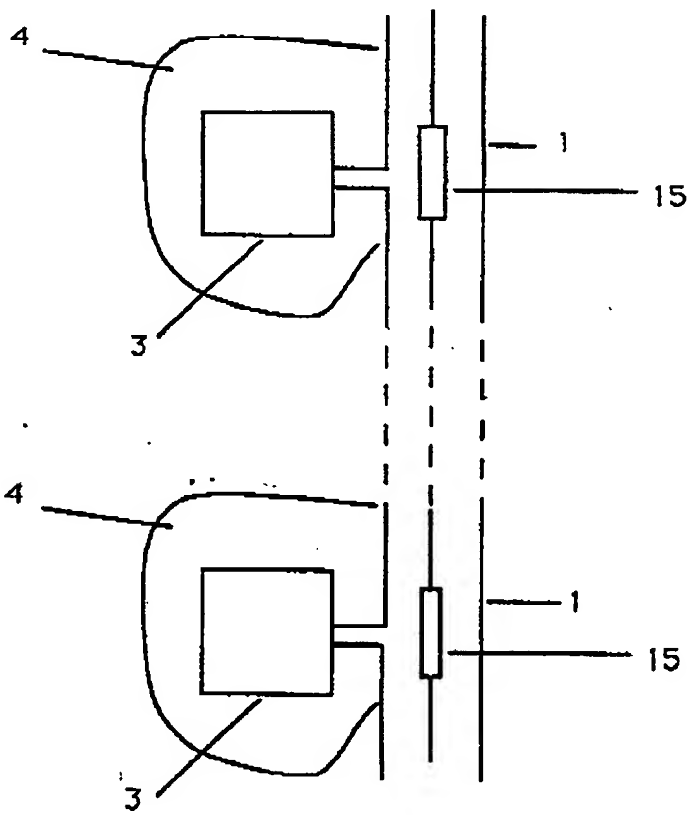

FIGURE 6

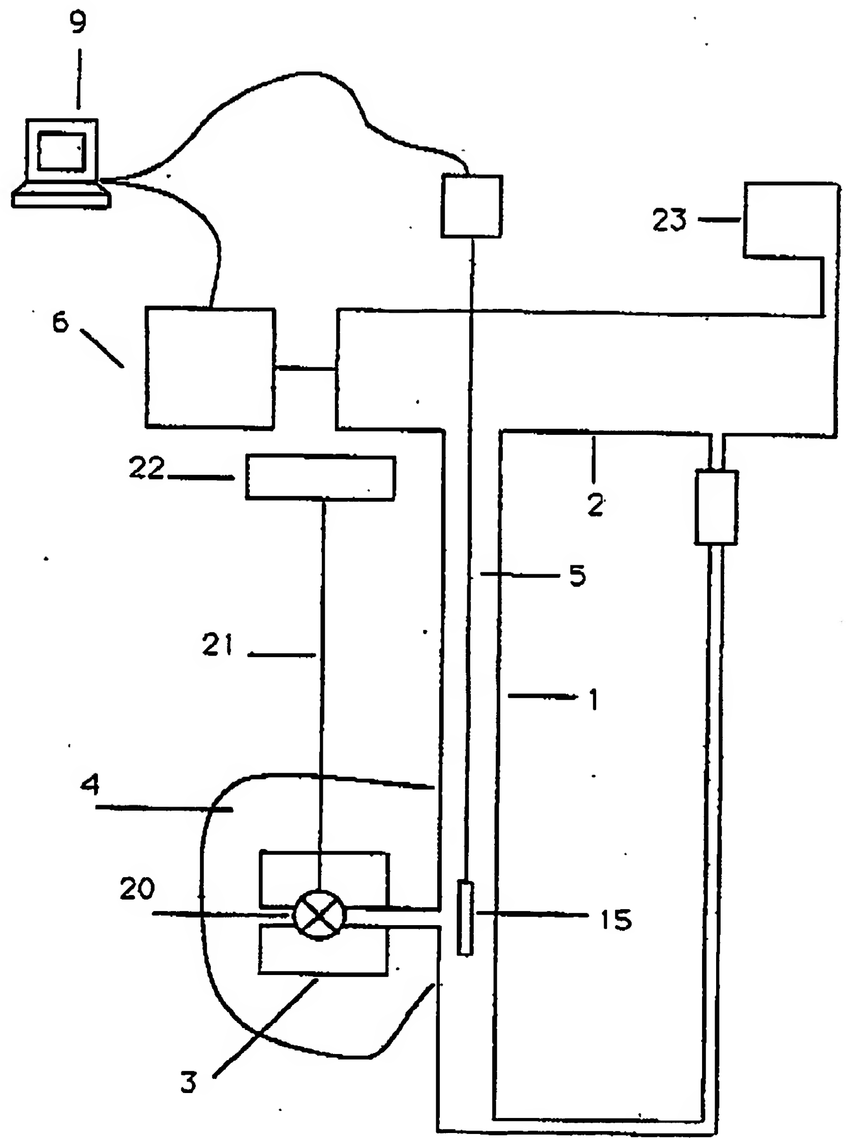

FIGURE 7

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 93/00907

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G01L19/00; E21B47/06; E21B23/08; E21B47/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G01L ; E21B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[°]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
A	EP,A,0 424 120 (BAROID TECHNOLOGY , INC.) 24 April 1991 see the whole document	1-2, 9-10,15
A	US,A,4 052 903 (THORDARSON) 11 October 1977 see column 4, line 26 - column 5, line 60; figures 1,6	1
A	US,A,4 010 642 (MCARTHUR) 8 March 1977 see column 4, line 40 - column 5, line 22; figures 1-2	1

° Special categories of cited documents :[10]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
12 AUGUST 1993	25. 08. 93
International Searching Authority: EUROPEAN PATENT OFFICE	Signature of Authorized Officer: ZAFIROPOULOS N.

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9300907
SA 73475

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 12/08/93
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-0424120	24-04-91	US-A- 4976142	11-12-90
		US-A- 5163321	17-11-92
		JP-A- 4189998	08-07-92
US-A-4052903	11-10-77	None	
US-A-4010642	08-03-77	BE-A- 828750	06-11-75
		CA-A- 1015177	09-08-77
		FR-A- 2274778	09-01-76
		GB-A- 1511513	17-05-78
		JP-A- 50153686	10-12-75
		NL-A- 7505287	10-11-75

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